DISSERTATION ON

The Use of Poller Screws in Proximal and Distal Metaphyseal Fractures of Tibia- A Prospective Study

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CERTIFICATE

Certified that the dissertation on “**The Use of Poller Screws in Proximal and Distal Metaphyseal Fractures of Tibia - A Prospective Study**’’ is a bonafide work done by **Dr.M.S.Mugundhan,** Postgraduate, Department of Orthopaedic Surgery, Kilpauk Medical College & Hospital, Chennai-10, under my guidance and supervision in partial fulfillment of the regulations of **The Tamilnadu Dr. M. G. R. Medical University** for the award of **M.S. Degree Branch II (Orthopaedic Surgery)** during the academic period of May 2006– March 2008.

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DECLARATION

I declare that this dissertation entitled **"The Use of Poller Screws in Proximal and Distal Metaphyseal Fractures of Tibia- A Prospective Study''** has been conducted by me at the Department of Orthopaedic Surgery, Kilpauk Medical College & Hospital, Chennai, under the guidance and supervision of my respected Chief **Prof. K. Sankaralingam, D. Ortho, M.S.(Ortho), DNB Ortho,** Government Kilpauk Medical College and Hospital, Chennai. It is submitted as part of fulfillment of the award of the degree in M. S. (Ortho) for the March 2008 examination to be held under The Tamilnadu Dr. M. G. R. Medical University, Chennai. This has not been submitted previously by me for the award of any degree or diploma from any other university**.**

Dr. M.S.Mugundhan

CONTENTS

INTRODUCTION

Treatment of metaphyseal fractures of tibia remains a challenge. The goals of surgical management include correction and maintenance of sagittal and coronal alignment, establishment of length and rotation and early functional range of movements of knee and ankle.

Treatment options include medullary implants, half pin, thin wire or hybrid external fixation, plate fixation or combination techniques[1].

Interlocking nailing of tibial fractures are desirable because this technique allows some load sharing , spares extraosseous blood supply, avoids extensive soft tissue dissection and is familiar to most surgeons[1].

Nailing of metaphyseal fractures with short proximal or distal fragment is associated with an increase in malalignment particularly in coronal plane, non union and need for secondary procedures to achieve union. The cause has been attributed both to displacing muscular forces and residual instability[2].

As there is a mismatch between the diameters of the nail and the medullary canal, with no nail-cortex contact, the nail may translate laterally along coronally placed locking screws and increased stress is placed on the locking holes to maintain fracture alignment after surgery[2].

Various techniques have been recommended to improve nailing the metaphyseal fractures including blocking screws (poller screw), temporary unicortical plating, different nail designs with different proximal bends (proximal third fractures) and fibular plating (distal third fractures).

AIM

To evaluate the clinical use of poller screws as a supplement to stability in metaphyseal fractures of tibia treated with statically locked intramedullary nail.

METAPHYSEAL FRACTURES OF TIBIA

Anatomy of Tibia

Shaft of tibia is triangular in cross section. Shaft of tibia expands at both the upper and lower ends to support body's weight at the knee and ankle joints.

Distal end of tibia is shaped like a rectangular box with a bony protuberance on the medial side (medial malleolus).

Metaphyseal fractures of tibia

Definition

Metaphyseal zone is defined as the area within a square the sides of which are the same length as the widest part of the articular surface[3].

Classifications

1. AO/OTA Classification

According to AO/OTA classification metaphyseal fracture of tibia in the proximal end is designated as 41 and in the distal end as 43. Type A is extra articular, Type B is partial articular and Type C is complete articular.

AO/OTA Classification of Proximal Tibial Metaphysis 41.

A – Extra articular fracture

A1 – Extra articular, avulsion

.1 Of the fibular head

.2 Of the tibial tuberosity

.3 Of the cruciate insertion

A2 - Extra articular fracture, Metaphyseal simple

.1 Oblique in frontal plane

.2 Oblique in sagittal plane

.3 Transverse

A3 - Extra articular fracture, Metaphyseal multifragmentary

.1 Intact wedge

.2 Fragmented wedge

.3 Complex

B – Partial articular fracture

B1 – Partial articular fracture, Pure split

.1 Of the lateral surface

.2 Of the medial surface

.3 Oblique, involving the tibial spines and one of the surfaces

B2 - Partial articular fracture, Pure depression

.1 Lateral total

.2 Lateral limited

.3 Medial

B3 - Partial articular fracture, Split depression

.1 Lateral

.2 Medail

.3 Oblique, involving the tibial spines and one of the surfaces

C – Complete articular fracture

C1 – Complete articular fracture, Articular simple, Metaphyseal simple

.1 Slight displacement

.2 One condyle displaced

.3 Both condyles displaced

C2 - Complete articular, Articular simple, Metaphyseal multifragmentary

.1 Intact wedge

.2 Fragmented wedge

.3 Complex

C3 – Complete articular fracture, multifragmentary

.1 Lateral

.2 Medial

.3 Lateral and medial

AO/OTA Classification of Distal Tibial Metaphysis 43.

A – Extra articular fracture

A1 – Extra articular, Metaphyseal simple

.1 Spiral

.2 Oblique

.3 Transverse

A2 - Extra articular fracture, Metaphyseal wedge

.1 Posterolateral impaction

.2 Anteromedial wedge

.3 Extending into the diaphysis

A3 - Extra articular fracture, Metaphyseal complex

.1 Three intermediate fragments

.2 > 3 intermediate fragments

.3 Extending into the diaphysis

B – Partial articular fracture

B1 – Partial articular fracture, Pure split

.1 Frontal

.2 Sagittal

.3 Metaphyseal multifragmentary

B2 - Partial articular fracture, Split depression

.1 Frontal

.2 Sagittal

.3 Of the central fragment

B3 - Partial articular fracture, Multifragmentary depression

.1 Frontal

.2 Sagittal

.3 Metaphyseal multifragmentary

C – Complete articular fracture

C1 – Complete articular fracture, Articular simple, Metaphyseal simple

.1 Without depression

.2 With depression

.3 Extending into diaphysis

C2 - Complete articular, Articular simple, Metaphyseal multifragmentary

.1 With asymmetric impaction

.2 Without asymmetric impaction

.3 Extending into diaphysis

C3 – Complete articular fracture, multifragmentary

.1 Epiphyseal

.2 Epiphyseo - metaphysis

.3 Epiphyseo - metaphyseo - diaphyseal

2. Taylor and Martin SUD classification of metaphyseal fractures

Taylor and Martin proposed a classification of metaphyseal fractures (SUD) in which the main fracture is characterised as stable (S), unstable (U) or with diaphyseal extension (D). These are furthur devided into three subtypes [4].

Taylor and Martin SUD classification of metaphyseal fractures

S-Stable

- S.0 - extra articular
- S.1 -<2mm displacement
- S.2 ->2mm displacement

U-Unstable

- U.0 - extra articular
- U.1 -<2mm displacement
- U.2 ->2mm displacement

D-Diaphyseal Extension

- D.0 - extra articular
- D.1 -<2mm displacement
- D.2 ->2mm displacement

According to Taylor and Martin with progression from type S to Type D, treatment shifts toward external fixator and away from open reduction. Conversely with progression from subgroup 0 to subgroup 2 open reduction is indicated[4].

Treatment options

Conservative treatment

Conservative management of metaphyseal fractures of tibia resulted in significantly high rate of complications.Sarmienta et al in 1989 concluded that bracing was contraindicated in fractures with excessive initial shortening or ones showing increasing angular deformity while in cast. Most series of closed treatment have reported 25 to 40% incidence of ankle and subtalar joint stiffness after prolonged casting and immobilisation[5, 6&7].

Plates and screws

Open reduction and plate fixation is also associated with a high incidence of soft tissue complications in the range of 10 to 15% in many sereis[8]. But the recent advances in plating techniques and designing have reduced these complications significantly. Indirect reduction and percutaneous plating (LISS- Less Invasive stabilisation System[9]) is indicated in a tibial shaft frcature with periarticular metaphyseal comminution that precludes locked intramedullary nailing and soft tissue damage of such severity that it precludes the use of standrad incisions according to Collinge and Sanders.

The incidence of late pain overlying the distal tibial and fibular plate or screw is not insignificant.

Hybrid fixator

Thomas A Russell preferred hybrid fixator or plate & screw technique with open or indirect reduction technique in metaphyseal diaphyseal transition or metaphyseal unstable fractures of tibia[5].

Bono CM et al proposed a treatment algorithm for proximal tibial fractures with minimal or severe soft tissue injury. He preferred external fixation or plating when the proximal fragment is short and nailing only when it is long[11].

Locked compression plate

Introduction of locked compression plate has changed the plating technique and the outcome in metaphyseal fractures significantly.

Though the locked compression plate with MIPO(Minimally Invasive Plate Ostesynthesis) technique eleminates the soft tissue problems associated with open reduction and internal fixation, it cannot help in fracture reduction. The fracture alignment has to be restored before applying the locked compression plate[12,13,14,15&16].

In the treatment of distal tibial fractures, locked compression plates provide more stable fixation than intramedullary nailing in vertical loading but were less effective in cantilever bending. In fracture patterns, in which the fibula cannot be effectively stabilised, locked plates offer improved mechanical stability when compared with locked nails[12]. In this study no supplementary procedure was done in the nailing group.

Complications associated with plating in metaphyseal fractures

1. Soft tissue complications in conventional open reduction and plating.

2. Development of superficial wound problems increased the risk of deep infection six fold[8].

3. Malalignment is more frequent in percutaneous plating than with other methods of fixation[4].

4. Fracture alignment could not be aided by the locked plate (no lag effect through the plate). It has to be restored before applying the plate[12].

5. Locked compression plating needs careful preoperative planning, if applied without following the principles of plating and the order of putting the screws, failures are not uncommon[17].

6. Late pain over the distal tibial and fibular plate or screw[18]

LITERATURE REVIEW

Evolution of interlocking nailing

Evolution of intramedullary nailing date backs to 500 years ago, it was recorded that Aztecs used wooden intramedullary nails[19].

In 1916 Hey Groves introduced a solid nail for tibia[19].

In 1940 Kuntscher introduced cannulated nails for tibia and femur. In 1950 Lottes one of the pioneers in tibial nailing developed a rigid nail for tibia[20].

In 1951 Herzog modified the Kuntscher nail, by adding a proximal bend to falicitate nail insertion.

Modney is credited with designing the first interlocking nail[4].

Kuntscher also desinged an interlocking nail (The Detensor nail, 1968) which was then modified by Klemm Schellumm initially and by Kempf and Grosse later in 1972[4].

In 1986 Bone & Johnson were the first to report interlocking nail in united states. They used Grosse Kempf interlocking tibial nail in 28 fractures of tibial shaft[20].

Charnley in his text “closed treatment of common fractures” stated that he believed the eventual solution to the tibial shaft fracture would be a non reamed intramedullary nail[5].

A fracture zone 5cm below the knee and 5cm above the ankle was required for effective use of interlocking nail. As the fracture line extend into the metaphyseal zones of the tibia, the stabiliy provided by any nail decreases precipitously[5].

Intramedullary nailing in tibial metaphyseal fractures

Closed, locked intramedullary nailing is now widely accepted as satisfactory treatment for tibial diaphyseal fractures. but there are concerns about the use of this technique for fracture in proximal and distal metaphysis[21].

Various supplementary procedures were used by different authors to effectively manage the metaphyseal fractures of tibia with intramedullary nailing.

Proximal tibial metaphyseal fracture

In 1996 Tornetta P III advocated semiextended position to prevent anterior translation and antecurvatum.

In 1997 Buchler et al and Tembcke et al suggested lateral entry point to prevent varus deformity.

In 2003 Laflamme et al proposed more oblique screws to maintain the alignment[33].

In 2006 Sean E Nork suggested temporary unicortical plating to achieve alignment[1].

Laflamme et al and Sean E Nork explained the wedging effect, when the proximal bend is distal to the fracture site. Hence they used nails with more proximal bend[33, 1].

Distal tibial metaphyseal fracture

In 1995 Robinson et al used percutaneous large reduction forceps to achieve the alignment and maintain the same throughout the nailing procedure. He also resected the distal few millimeters of the standard AO nail to nail the 4cm length distal metaphyseal fragments and used on of the distal locking bolts as lag screw through the fracture site[41].

In 1997 Thompson KA et al and Weber TG et al showed excellent results when supplemented with fibular plating[40, 30].In 2000 Tyllianaki also found fibular plating as an effective supplement[42].

1n 2002 Goezyca et al published their results of modified tibial nails for the distal metaphyseal fractures[32].

In 2003 James Kellam stated that fibular plating or poller screw were effective as supplementary techniques in intramedullary nailing of distal tibial metaphyseal fractures[35].

In 2005 Sean E Nork et al compared the results of those treated with nailing alone and those treated with supplementary fibular plating[31].

In 2006 Kenneth A Egol et al advocated fibular plating and temporary unicortical plating[34].

Poller screw

Poller screws placed adjacent to the nail and perpendicular to the screw holes usually in an anteroposterior direction had been suggested as one possible method of improving the stability of metaphyseal fractures and had been described as a reduction tool used to over come the displacing forces at the time of introduction of intramedullary nail.

The poller screws functionally decrease the width of the metaphyseal medulla and are particularly useful with nails of smaller diameter[2].

In 1994 Krettek et al described the clinical application of blocking screws, termed poller screws as a tool for the prevention of axial deformities of proximal and distal third fractures of tibia during intra medullary nailing. The same technique has been used for femoral fractures also[22,23].

The term **"poller"** was derived from small metal devices placed in roads to block or guide traffic[2].

Pathophysiology of intramedullary nailing

Nailing without reaming

Smaller diameter implants are used in nail insertion without reaming.

The benefits are less heat production and less disturbances of the endosteal blood supply.

There is also considerably less bone necrosis, which appears to be one of the risk factors for the development of post operative infection.

The influence of nail diameter on blood perfusion and mechanical parameters studied in dog models by Hupel TM et al. Following segmental osteotomy of the tibia, it was shown that a loose fitting nail did not affect cortical perfusion as much as tight fitting nail and it allowed more complete cortical revascularisation at 11 weeks post nailing. On the other hand stifness and load to failure were not found to be different.

Nailing with reaming

Nailing with reaming produces various local and general changes in the body.

Local Changes

Reaming the medullary cavity causes damage to the internal cortical blood supply, which in animal experiments was shown to be reversible within 8-12 weeks. This reduced blood supply during the early weeks after trauma and reaming might account for the increased risk of infection, especially in open tibial fractures. Because of infection rates as high as 21%, the use of reamed intramedullary nails in open fractures, even on a delayed basis, was not recommended.

General Changes

These include pulmonary embolisation, temperature related changes of the coagulation system and humoral, neural and inflammatory reaction.

The development of post traumatic pulmonary failure following early femoral nailing in the multiply injured patients is associated with the reaming procedure.

Wenda et al measuring intramedullary pressure intra operatively, found values between 420 - 1510 mm Hg with reaming procedures, as compared with 40-70 mm Hg in cases where solid nails were used without reaming.

MAIN OUTCOME MEASUREMENTS

Alignment and reduction pre operatively, post operatively and at healing was the main outcome measured with an emphasis on loss of initial reduction on follow up.

PATIENTS AND METHODS

This was a prospective study of 20 cases of tibial metaphyseal fractures treated with statically locked intra medullary nailing with supplementary poller screws between August 2006 and September 2007 at Kilpauk Medical College.

Inclusion Criteria

Displaced tibial metaphyseal fractures of proximal or distal third in adults treated with intramedullary nailing were included in the study.

The fractures included were acute fractures and delayed union.

Both open and closed fractures were included in the study.

Exclusion Criteria

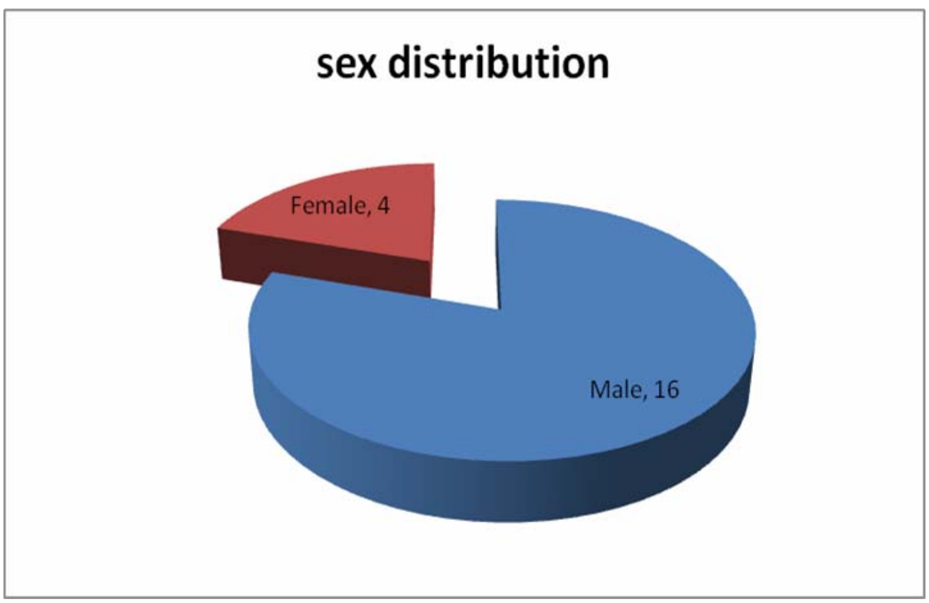
Tibial diaphyseal fractures were excluded from the study.

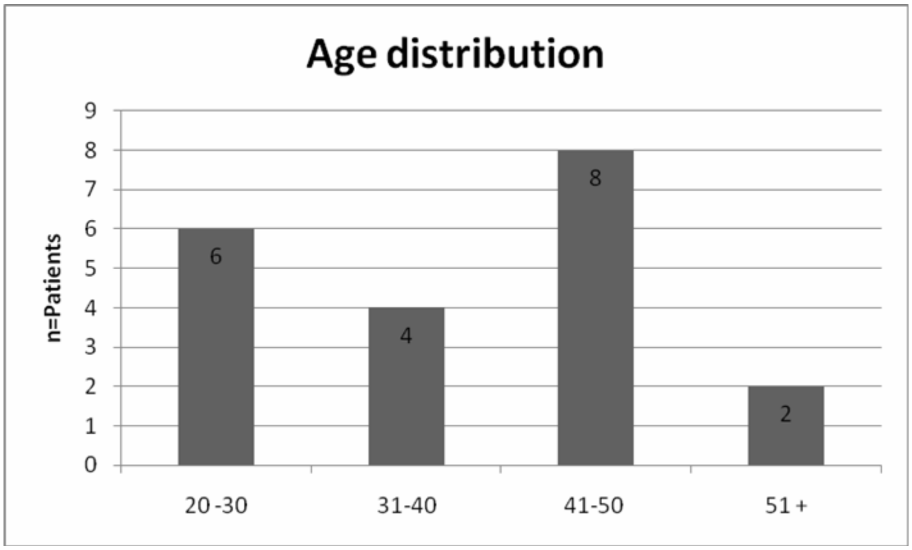
Metaphyseal fractures treated with statically locked intramedullary nails but with additional procedures like fibular plating were excluded from the study.

Patients

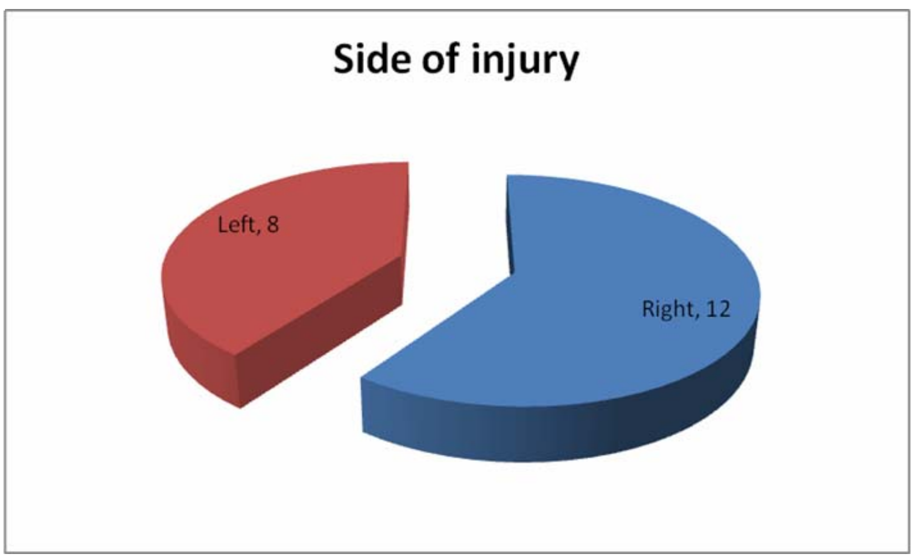
Among the operatively treated 65 tibial fractures between August 2006 and September 2007 at Kilpauk Medical College 20 cases met the inclusion criteria.

There were 16 males and 4 female patients with a mean age of 37.75 years [95% lower confidence limit of (LCL) 33.13 years and 95% upper confidence limit of (UCL) 42.36].



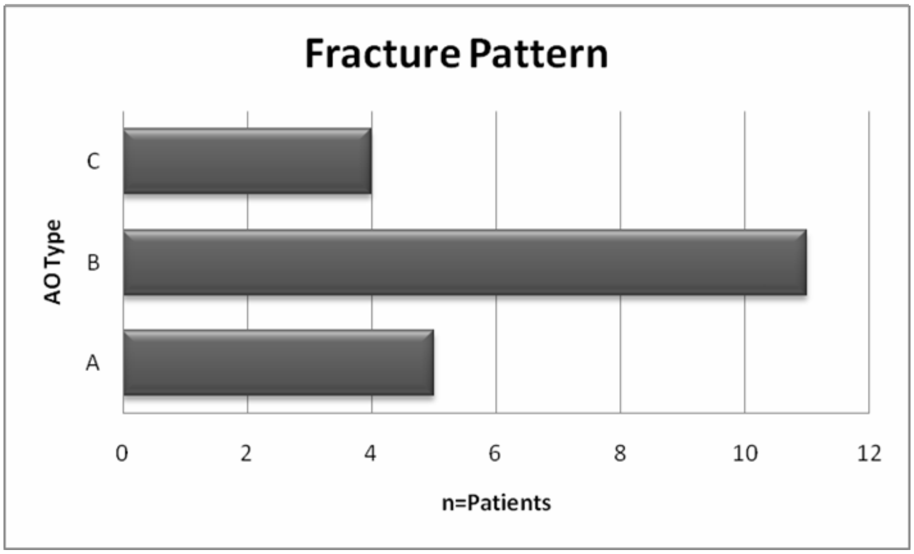


The injury was on the right side in 12 cases.

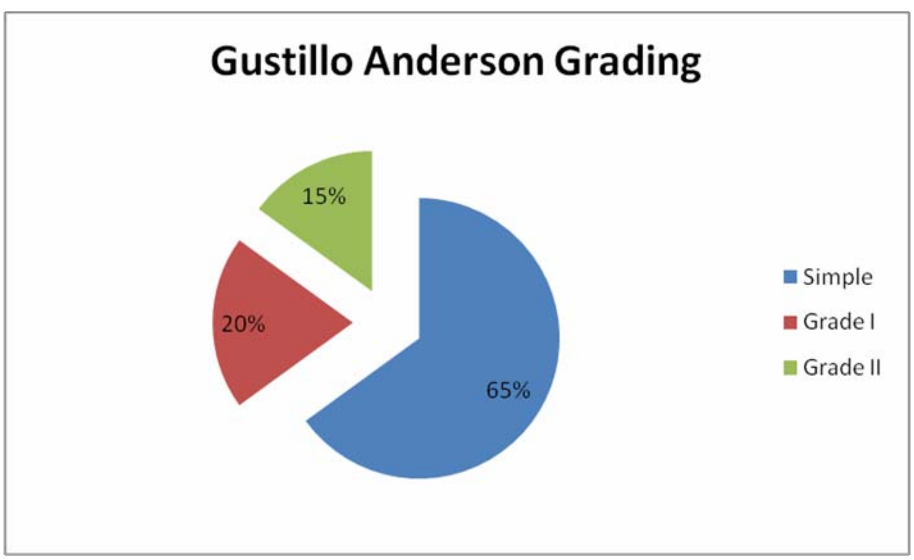


The mechanism of injury was Road traffic accident in all except three in whom it was fall from height in two and fall of a heavy object over the leg in one.

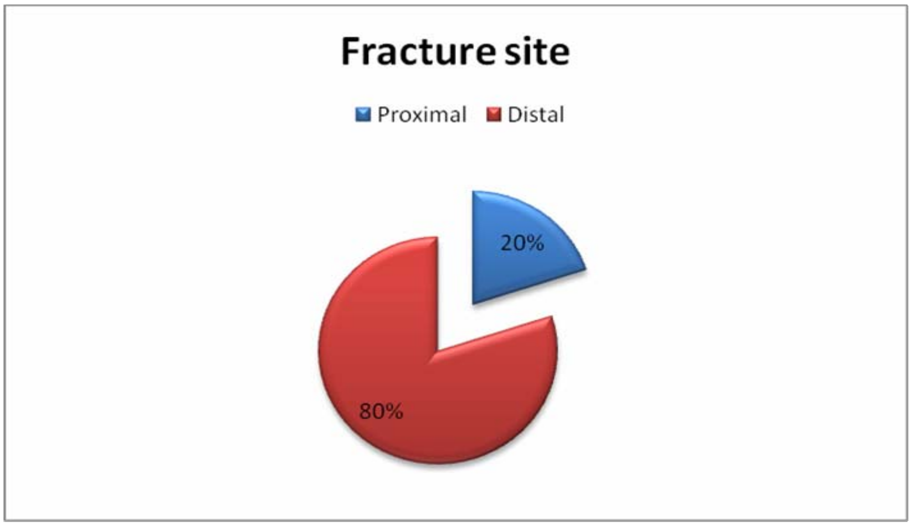
According to AO guidelines there were five type A, eleven type B and four type C fractures.



Injury was closed in 15 fractures and Gustillo Anderson grade I in 2 and Grade II in 3 patients.

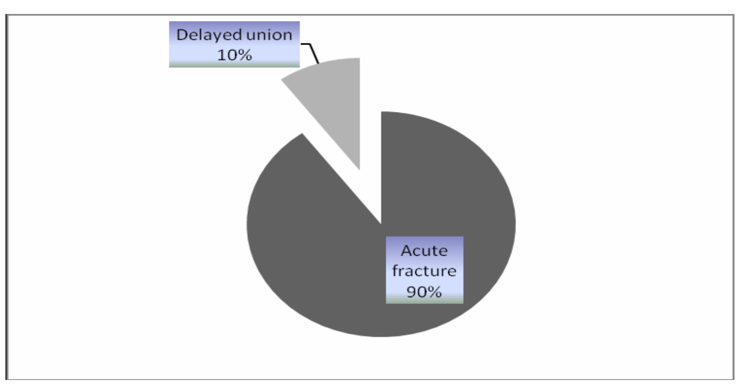


Among the 20 fractures 4 were proximal third and 16 were distal third fractures.



The mean distance from the articular surface was 5.27 cm (95% LCL 4.20cm and 95%UCL 6.34cm) and the mean length of the fracture was 3.4cm (95% LCL 2.69cm and 95%UCL 4.10cm).

The mean delay between the injury and the surgery was 3.75 weeks (95% LCL 1.23weeks and 95%UCL 6.26 weeks). Among the 20 cases two were delayed union of 18 weeks duration.



The mean operating time was 75 minutes.

The mean diameter of the medullary canal at the level of isthmus was 11.9 mm and at the fracture site was 22.9 mm.

The mean length of distal metaphysis was 5 cm and the proximal metaphysis was 7.7 cm.

Medullary canal diameter (in mm)

	Mean	**S.D**	**95% LCL**	**95% UCL**
Isthmus	11.9	1.7	11.1	12.7
Fracture site	22.9	6.6	19.8	25.9
Distal metaphysis	50.2	3.5	48.5	51.8
Proximal metaphysis	76.6	6.5	73.5	79.6

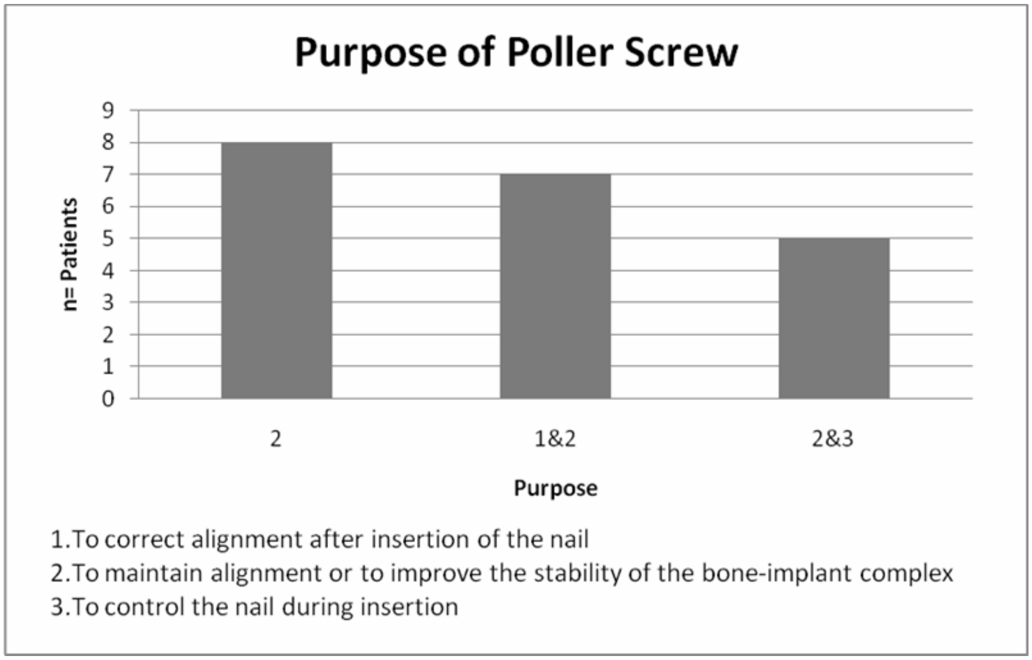
Poller screws

Poller screws were selected for use for one or more of the following reasons

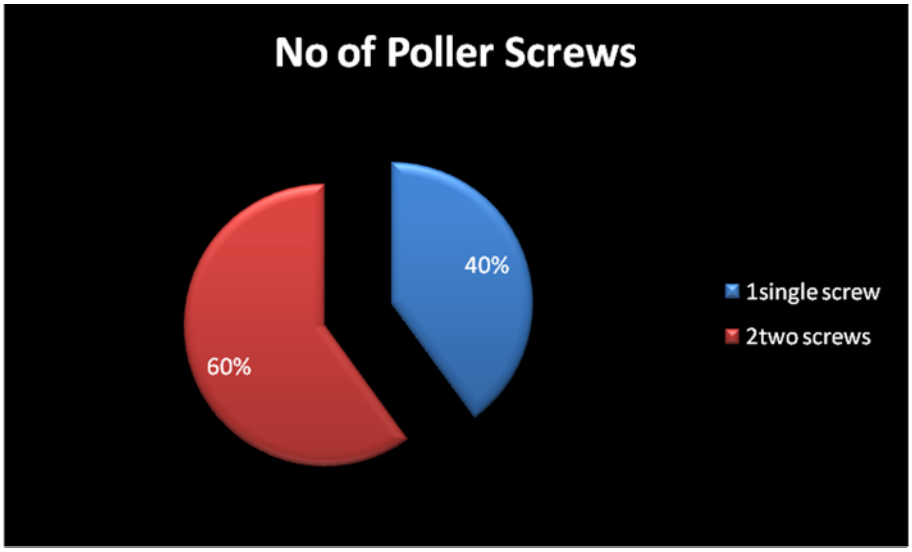
1. To correct alignment after insertion of nail (8 fracture)

2. To maintain alignment or to improve the stability of bone implant complex (20 fractures)

3. To control the nail during insertion (5 fractures).



In 8 cases single poller screw was used on the concave side of the deformity, close to the fracture site in the short fragment and in rest of cases 2 poller screws were placed, the second screw on the convex side of deformity near the end of the nail in the short fragment .



Depending on the amount of correction needed the screws used for blocking were locking screws of different sizes or 4.5mm cortical screws.

OPERATIVE PROTOCOL

Pre operative planning

X ray of the injured leg in AP & Lateral views, were taken. The fracture tendency for valgus or varus and antecurvatum or recurvatum malalignment was noted. The angle of malalignment was measured.

Fracture was classified according to AO.

Fracture location from the proximal or distal articular surface was measured. The length of fracture was also measured. The diameters of medullary canal at isthmus and at the level of fracture were measured.

Appropriate length of the nail was measured in the contralateral leg, from the tibial tuberosity to medial malleolus.

Open fractures were delt with according to AO principles.

Operative Technique

Metaphyseal fractures were stabilized with statically locked intramedullary nails on a standard radio lucent table with manual traction.

All cases were done under spinal anaesthesia. Tourniquet was not used in any case. Through patellar tendon splitting approach, entry point was made in the midline. Guide wire was passed under image intensifier control.

Closed reduction was done in all except two fractures. In those fractures, closed reduction was attempted and we had to do open reduction as there was a marked overriding of the fragments and delay of 18 weeks before surgery.

The nails used were unreamed cannulated stainless nail, with 2 proximal (mediolateral) and 3 distal (2 mediolateral and 1 anteroposterior) locking options, of diameter 8 or 9 mm. In one case the tibia was too narrow and too short where we have used a nail of 7 mm diameter.

The poller screw was used on the concave side of the deformity close to the fracture in the short fragment when single screw was used between the cortex and the nail under image intensification. When 2 poller screws were placed, the second screw was on the convex side of deformity near the end of the nail in the short fragment.

In cases of malalignment and instability the screw holes were drilled with the nail in place while applying manual over correction. 2.5 or 3mm K wire was used to drill the pilot hole for poller screw as the drill bit may damage the nail while drilling with the nail in-situ.

For fractures which were stable but malaligned, the nail was temporarily removed, the poller screws were placed and the nail reinserted.

Distal and proximal locking was done after achieving the alignment using poller screws.

The alignment was confirmed in both coronal and sagittal plane with image intensifier.

Post operative treatment

Partial weight bearing was started in second postoperative week in all except two cases. In one where we have used 7 size nail, we recommended non weight bearing till radiological evidence of union and in the other were tibialis anterior tendon was found cut and the patient had both bones fractures in the contra lateral leg, partial weight bearing could not be started. In both the cases cast support was given for 4 weeks.

Partial weight bearing continued up to 4 to 8 weeks thereafter full weight bearing started depending on clinical and radiological evidence of union.

Follow up

All the fractures were followed through till union of fracture with clinical and radiological examination at intervals of 4 to 6 weeks. The maximum follow up was 16 months. .

On follow up axial alignment was assessed and functional analysis was quantified using Karlstorm- Olerud score.

Valgus and antecurvatum were expressed as positive values and varus and recurvatum were expressed as negative values.

Radiographs were analyzed for correction, maintenance of position or loss of reduction.

Shortening and rotational malalignment were not measured.

Fracture was defined as united when patient was able to bear full weight on the injured limb without pain and without support and when radiographs showed bridging callus in at least 3 cortices.

Complications

Complications were divided into those which were related to poller screw and those which were not.

Complications related to poller screw may be mechanical instability leading to non union, new fracture lines through the holes for poller screws, nail failure due to damage by the drill, breakage of poller screw and nerve, tendon or vascular injury due to poller screw insertion[2]. We encountered only new fracture line through the holes for poller screw in one case.

Complications not related to poller screw may be compartment syndrome, infection, rotational mal alignment, breakage of locking screw and nerve, tendon or vascular injury before insertion of poller screw[2]. In our series we had only two cases of deep infection and one case of tendon injury.

DATA ANALYSIS

Data analysis was done using repeated measures ANOVA test.

Repeated measures designs are popular because they allow a subject to serve as their own control. This improves the precision of the experiment by reducing the size of the error variance on many of the F-tests[24]. In our study since there was no control group repeated measures ANOVA test was chosen.

Within-subject designs are those in which multiple measurements are made on the same individual at different point of times[24]. Here the variables in our study were the angle at the fracture site measured within the subjects at different point of times.

95 % upper and lower confidence limits were preferred over range to express the variables as few extreme values of variables of normal distribution should not mislead the interpretation of analysis[24].

Karlstorm-Olerud score was used to asses the functional outcome. It is an independent measurement, not influenced by other co-morbid conditions and associated injuries[25].

Parameters of Karlstorm- Olerud scoring system were

1. Residual angulation (0 to 3 points)

    0˚ -- 0 point

    1 to 3˚ -- 1 point

    4 to 5˚ -- 2 points

    >5˚ -- 3 points

2. Fracture Healing (0 to 3 points)

    Union < 12 weeks -- 0 point

    Delayed union >12 weeks -- 1 point

    Delayed union requiring secondary procedures -- 2 points

    Non union > 6 months -- 3 points

3. Cast Support (0 to 1 point)

    No cast support -- 0 point

    Cast support -- 1 point

Outcome

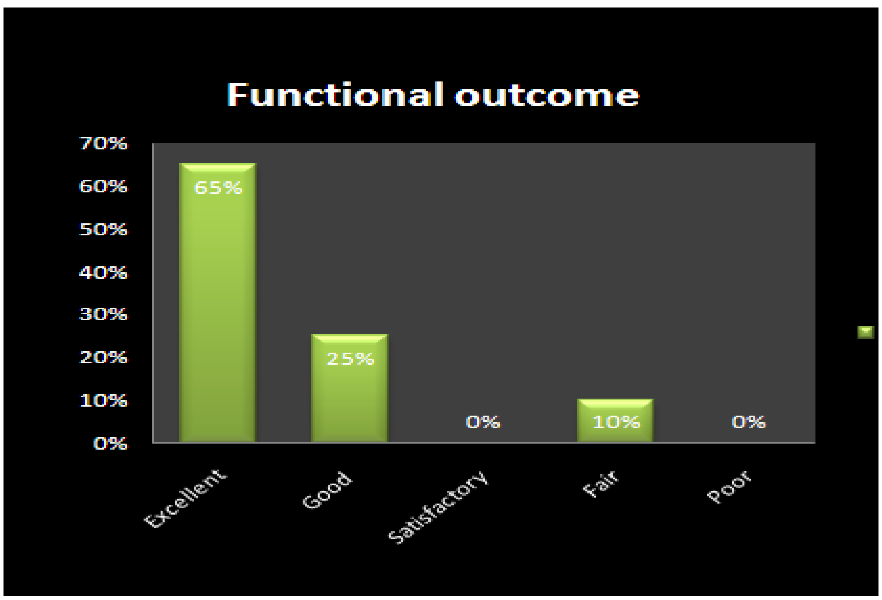
0 & 1 points	Excellent
2 & 3 points	Good
4 points	Satisfactory
5 points	Fair
6 & 7 points	Poor

RESULTS

All the relevant data were analysed.

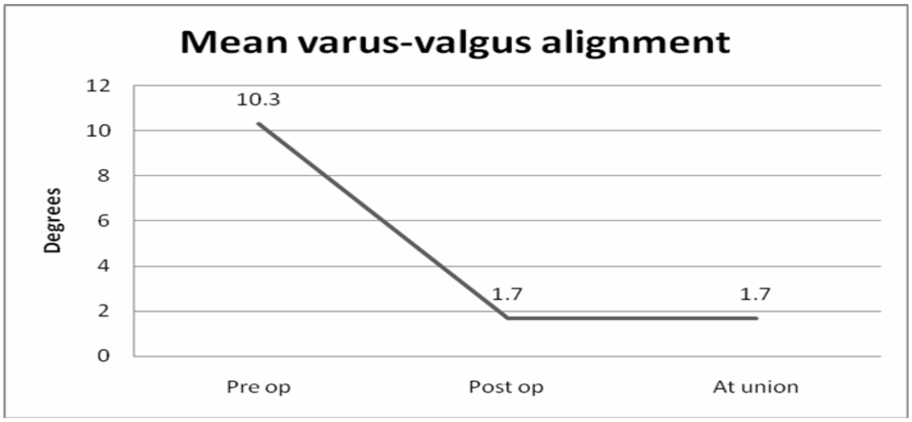
All the fractures eventually united in a mean period of 11.5 weeks (95% LCL 10.11weeks and 95%UCL 12.88 weeks).

Karlstrom-Olerud score was excellent in 13 fractures (65%), good in 6 patients (25%) and fair in 2 patients (10%).



Radiologically the mean post operative varus/valgus alignment was $\pm$1.7 degrees (95%LCL 0.5 degrees and 95% UCL 2.9 degrees) when compared to the mean preoperative varus/valgus alignment of $\pm$10.3 degrees (95%LCL 8.2 degrees and 95% UCL 12.4 degrees).

The alignment was maintained till union with the mean remaining the same in the coronal plane.



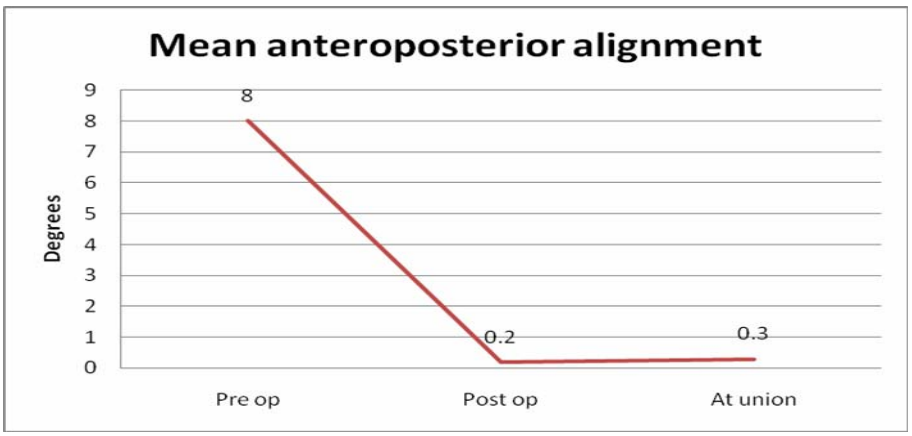
	N	Mean (in degrees)	Standard deviation
Pre op	20	10.3	4.5
Post op	20	1.7	2.5
At union	20	1.7	2.5

Repeated measures ANOVA test showed the F-test value of 45.29 which is significant as the *p* value is 0.00000(p <0.05).

The mean post operative antecurvatum/ recurvatum alignment was $\pm$0.2 degrees (95%LCL -0.1 degrees and 95% UCL 0.5 degrees) when compared to the mean preoperative antecurvatum/ recurvatum alignment of $\pm$8.0 degrees (95%LCL 4.6 degrees and 95% UCL 11.3 degrees). F test value in repeated measures ANOVA is 22.845 with a *p* value of 0.0000(<0.05) which is statistically significant.

In only one case of proximal third tibial fracture there was a loss of initial reduction in sagittal plane of 2 degrees, where no poller screw was used in the sagittal plane.

The mean antecurvatum/ recurvatum alignment at the time of union was $\pm$0.3 degrees, the loss of alignment was not statistically significant.



	N	Mean (in degrees)	Standard deviation
Pre op	20	8.0	7.1
Post op	20	0.2	0.6
At union	20	0.3	0.7

The mean ratio of fracture segment to the nail length (i.e the length of tibia) was 15%.

The poller screw related complication was encountered in one case where we had new fracture lines while introducing the nail after placement of poller screw. But the alignment was achieved and maintained and the fracture united within 12 weeks.

Complications which were not related to poller screw were encountered in three cases. Two patients had deep infection and both of them went in for delayed union of which one required dynamisation to achieve union. In one patient tibialis anterior tendon was found cut at the time of open reduction of the fracture and was repaired. He was given cast support for four weeks.

No complications of nerve injury or compartment syndrome were encountered. There were no incidences of breakage of nail, locking screw or blocking screw.

DISCUSSION

Fracture union was rather difficult to define and measure. Sarmiento et al in 1984 specified criteria for the judgment of union[50].

1. The ability of the patient to bear weight without pain.
2. Absence of clinically detectable movements across the fracture site.
3. Visible bridging callus across the fracture on plain radiograph.

In case of operative treatment this criteria doesn’t hold good. Panjabi et al in 1985 proved that cortical continuity was the best predictor of mechanical strength and the author suggested that measurement of number of cortices bridged was the most reliable measure to assess fracture healing[50].

In our series, the union was defined as achieved when the patient was able to bear weight in the injured leg without pain and when the radiograph showed bridging callus in at least three cortices.

We cannot over emphasize the potential advantages of intramedullary nailing than any other form of fixation like external fixator or plating in tibial fractures. But the problems in extending the indications to metaphyseal fractures have to be analyzed and resolved.

In 1995 Lang GJ et al questioned the use of inter locking nailing in proximal third fractures in his review of 32 cases of proximal third fractures. He encountered 84 % of malunion i.e. angulations of 5 degrees or more in frontal or sagittal plane and required secondary procedures to achieve union in 41 % of cases. Hence he suggested alternate forms of fixation like plate or external fixation[26].

Sean E Nork et al, in their review stated that previously reported rates of unacceptable alignment after medullary nailing of proximal third fractures have ranged from 58% to 84%[27].

Ahlers and Von Issendorf analysed 386 fractures of tibia treated by intra medullary nailing of which 32 were proximal and 138 were distal third fractures. In both the groups one quarter to one third had varus- valgus deformities greater than 4 degrees[28].

In another study, Moshieff in 1999 found that 42 % of distal third fractures treated with inter locking nailing required secondary procedures to achieve union[28].

There has been discrepancy in the literature regarding the locking bolt orientation and its effect on fracture nail construct stability.

Chen AL compared the intrinsic stability in tibial intramedullary nail constructs in distal third diaphyseal fractures without isthmal support, between two mediolateral distal locking screws and two perpendicular (one mediolateral & one anteroposterior) distal locking screws. He concluded that fixation stability of intramedullary nail is not significantly influenced by distal locking screw orientation in response to sagittal, coronal or rotational forces[30].

In contrary, Smucker et al found two parallel locking bolts being a better construct than perpendicular locking bolts in their study[31].

To overcome these issues various techniques have been developed.

In proximal third fractures proximal and lateral entry point was suggested by Buehler KC et al and Lembcke O et al. Use of semi extended position was proposed as a solution by Tornetta P III[1].

Temporary unicortical plating with or without medial femoral distractor was used efficiently to achieve reduction in proximal third fractures by Sean E Nork et al and Dunbar RP et al.

Modifications in nail designs including different proximal bends and more oblique screws have also been put forth as effective solutions[1,33].

In distal third fractures fibular plating and cutting the distal few millimeters of nail distal to the distal screw hole to allow two cross locking screws in the distal fragment, one cross screw across fracture site as lag screw and use of large reduction forceps and temporary unicortical plating, percutaneous manipulation with Shanz pins, femoral distractor have been the supplementary procedures used to achieve the alignment[31,32,34,35,36,37,38,39,40,41,42].

The amount of malalignment and shortening considered acceptable is controversial. Tarr et al and Puno et al demonstrated that distal tibial malalignment may be more poorly tolerated than more proximal malalignment[4.]

Trafton's recommendation is generally agreed by many authors. As per Trafton's recommendation the acceptable malalignment is less than 5 degrees of varus-valgus angulation, 10 degrees of anteroposterior angulation, and 10 degrees of rotation and 15mm of shortening[4]. In our study we encountered malalignment in two cases of distal third fracture and in one proximal third fracture (15%).

Criteria traditionally used to diagnose a tibial malunion [50]

(After Lindsey & Blair 1996)

Authors	Varus	Valgus	Anterior / Posterior
Bone & Johnson, 1986		5	
Bostman 1983	5	5	
Collins et al 1990	5	5	5-10
Haines et al 1984	4	4	
Jensen et al 1977	8	8	15
Johner & Wruh 1983	5	5	10
Nicoll 1964	10	10	10
Puno et al 1991	10	10	20
Trafton 1988	5	5	10

Effect of mal union

Importance of achieving anatomical reduction in fractures of tibia cannot be over emphasized.

Merchant and Dietz in 1989 suggested that for tibial fractures deformity of >5°C was associated with radiographic changes in the ankle[50].

Van der Schoot reported a 15 year follow up of 88 patients with fractures of lower leg. 49 % had healed with malalignment of at least 5 degrees. More arthritis was found in the knee and ankle adjacent to fracture than in comparable joints of the uninjured leg. Malaligned fractured showed significantly more degenerative changes[43].

Puno RM et al recorded the long term effects of tibial angular malunion on knee and ankle joints in his 28 tibial fractures with an average follow-up of 8.2 years. His analysis showed greater degrees of ankle malalignment produce poorer clinical results[44].

Kyro A in his series of 64 tibial shaft fractures concluded that malunion of tibial shaft fractures seem to be especially harmful in distal fractures, in fractures with marked previous displacement, in fractures caused by high energy injury and among patients less than 45 years of age[45].

We have analysed the mismatch between the diameters of medullary canal at the level of isthmus (i.e. maximum possible nail size) and at the fracture site in all cases.

We found that there was a significant $p = 0.0000$ ($p < 0.5$) mismatch between them. The diameter of medullary canal at the level of isthmus was 11.9 mm compared to 22.9 mm at the level of fracture site. This mismatch explained the cause of instability in metaphyseal fractures when treated with intramedullary nailing.

We have also measured the maximum diameter of the metaphysis both at proximal and distal tibia, there by the length of the metaphyseal segment in our population was arrived. The mean length of proximal metaphysis was 7.7 cm and of distal metaphysis was 5.0 cm.

The primary aim of the study was to analyze the effectiveness of achieving and maintaining reduction in metaphyseal fractures of tibia treated with intramedullary nailing using supplementary poller screws.

As described in various literatures the malalignment in these circumstances were significantly high when done without any supplementary procedures.

Krettek et al in 1999 published the mechanical effect of blocking screw in stabilizing tibial fractures with short proximal or distal fragments after insertion of small diameter intra medullary nails. He created bone implant constructs (BIC) in fresh cadaveric tibiae and demonstrated in distal BICs the addition of blocking screws decreased the average deformation of the BICs 57% [$p<0.0001$] and in proximal BICs the addition of blocking screws decreased the average deformation of BICs 25% [$p<0.0001$] [46,47].

The effectiveness of blocking screws to help obtain and maintain alignment of fractures of proximal third tibial shaft treated with intra medullary nailing was established by Ricci et al in his series. [48]

Ai J et al explored the effect of blocking screws on the breakage of inter locking intramedullary nails and concluded that blocking screws improve the stability of fracture area distinctively and hence reduce the breakage of intra medullary nailing[49].

James Kellam in his commentary and perspective on the effect of fibular plate fixation on stability of simulated distal tibial fractures treated with intramedullary nailing by Anand Kumar et al concluded that meticulous intramedullary techniques combined with the use of fibular plate fixation or blocking screws will achieve the best results in maintaining the reduction of distal tibial fractures till union[35].

Kenneth A Egol compared the loss of alignment in distal metaphyseal fractures treated with intra medullary nailing alone and in conjunction with fibular plating. They had immediate post operative malalignment in three cases in those treated with nailing alone, which were eventually corrected by using blocking screws[34].

Oh CW had encountered malalignment of 14% in poller group and 63% of non poller group in his review of 33 fractures of proximal tibia[51].

The use of poller screw as reduction tool was established in our study by the repeated measures ANOVA test and was comparable to the study by C.Krettek.

Poller screws improved the stability of the metaphyseal fractures after nailing and promoted union in our study. Secondary procedure was required in only one case to achieve union (5%). Dynamisation was done 6 weeks after interlocking nailing in a proximal third fracture who developed deep infection. The fracture was originally a grade II compound fracture treated with external fixator which was removed once the wound healed. Nailing was done 6 weeks after removal of fixator.

No cases required bone grafting, bone marrow injection or exchange nailing.

The ratio of short metaphyseal fragment length to the total tibial length was analysed. The total length of the tibia was approximately derived from the length of the nail used.

The mean ratio was found to be 15%.

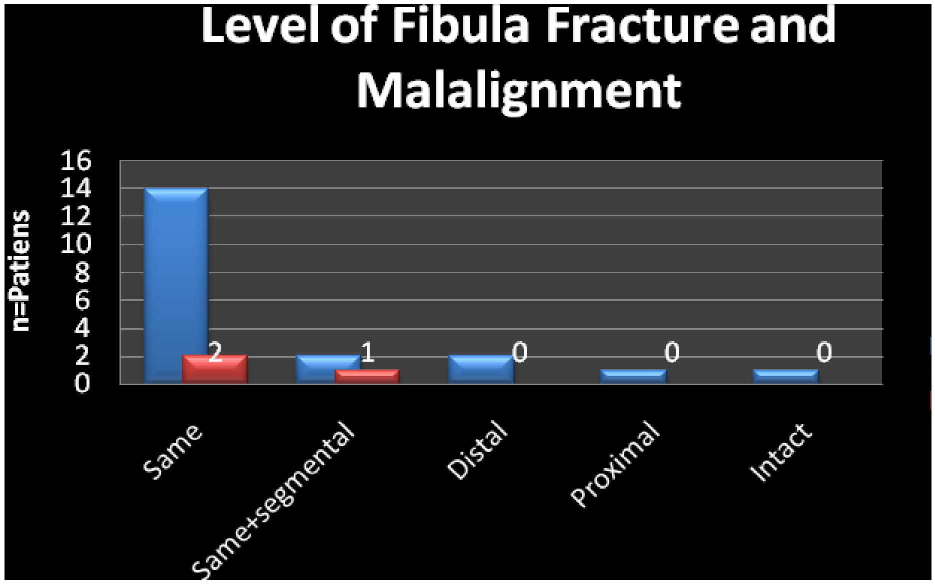
This indicates that even such short metaphyseal fragments had been effectively stabilized till union with intramedullary nailing when supplemented with poller screw.

Poller screws functionally reduce the width of the metaphyseal medulla, usually it is applied in anteroposterior direction as the coronal plane malalignment is more prone to occur than the sagittal plane. Moreover deformities in the sagittal plane is better tolerated, are less common if the fracture is reduced at the time of initial locking. But when the fracture pattern suggests instability in sagittal plane poller screw should be used in the mediolateral direction.

The reduction should be ensured in two planes with image intensification after placing the poller screws and before applying the locking screws.

Paige Whittle A and George W Wood II in their analyses of influence of fibular fractures on maintaining alignment in 40 distal tibial fractures treated with locked intramedullary nailing concluded that 60% of unfixed fibular fractures occurring at the same level as the tibial fracture were malaligned.

In our study, fibular fracture was associated in all but one patient. It was at the same level of tibial fracture in 16 cases, distal to tibial fracture in 2 patients of distal metaphyseal fractures (at the level of syndesmosis) and was segmental in 2 cases. Only 17.5 %(3/16) of unfixed fibular fractures occurring at the same level as the tibial fractures, were malaligned, which is not significant.



We found that interlocking nailing when supplemented with poller screw, level of fibula fracture did not influence the stability or the functional outcome

When compared to other techniques described for preventing metaphyseal malalignment during nailing, poller screws are technically easy, reproducible, do not require any special instrumentation and do not need any special design modifications in the nail. There is no need for excessive soft tissue dissection or additional hardware like unicortical plating or fibular plating. There is no significant increase in radiation exposure for applying poller screws.

In our series the mean ratio of fracture segment to the tibial length was only 15% which denotes that even such short fracture segments can be safely and effectively managed by intramedullary nailing when supplemented with poller screws.

We had excellent to satisfactory outcome in 90% by Karlstrom-Olerud scoring which is comparable to the results of C.Krettek et al with 94% excellent to satisfactory.

CONCLUSION

We conclude that Poller screws, when supplemented the intramedullary nailing of metaphyseal fractures of tibia,

1. Were effective in achieving the fracture alignment, acting as a reduction tool
2. Improved the stability of the bone – implant construct, by functionally reducing the medullary width
3. Maintained the fracture alignment till union, preventing loss of initial reduction.

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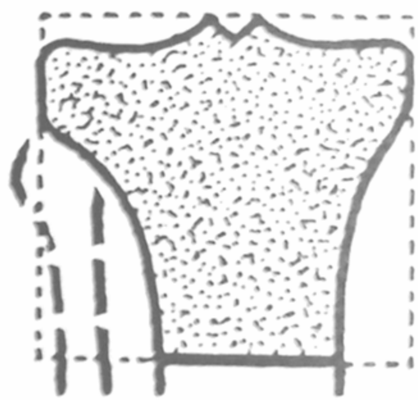
Metaphyseal zone of proximal tibia



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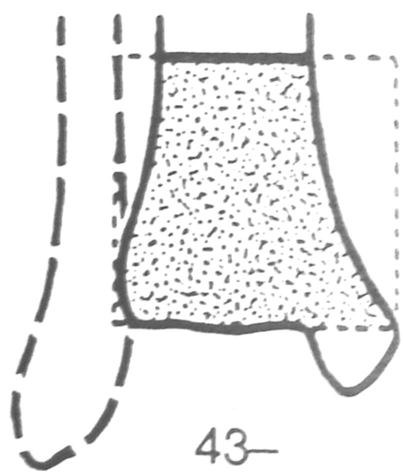
Metaphyseal zone of distal tibia



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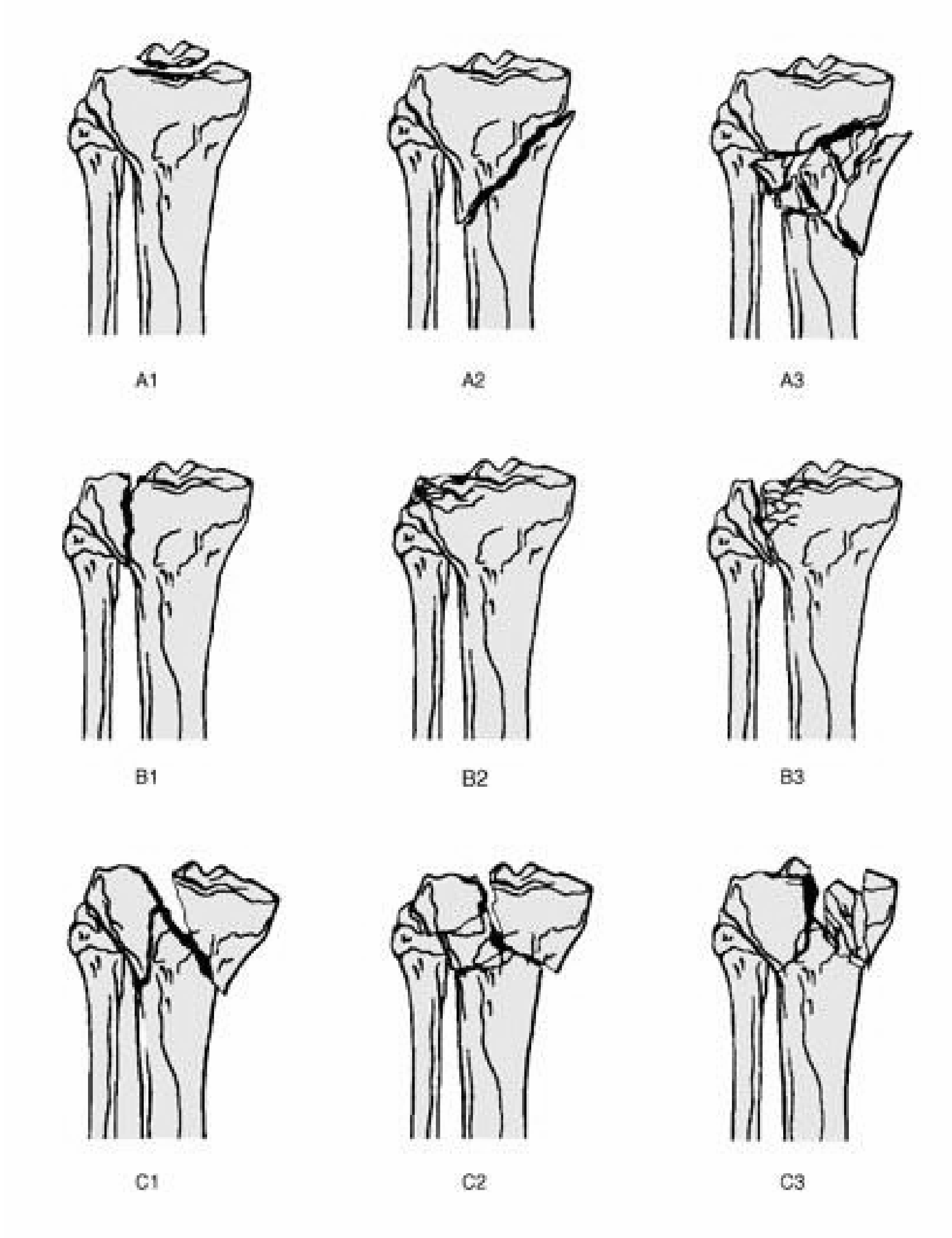
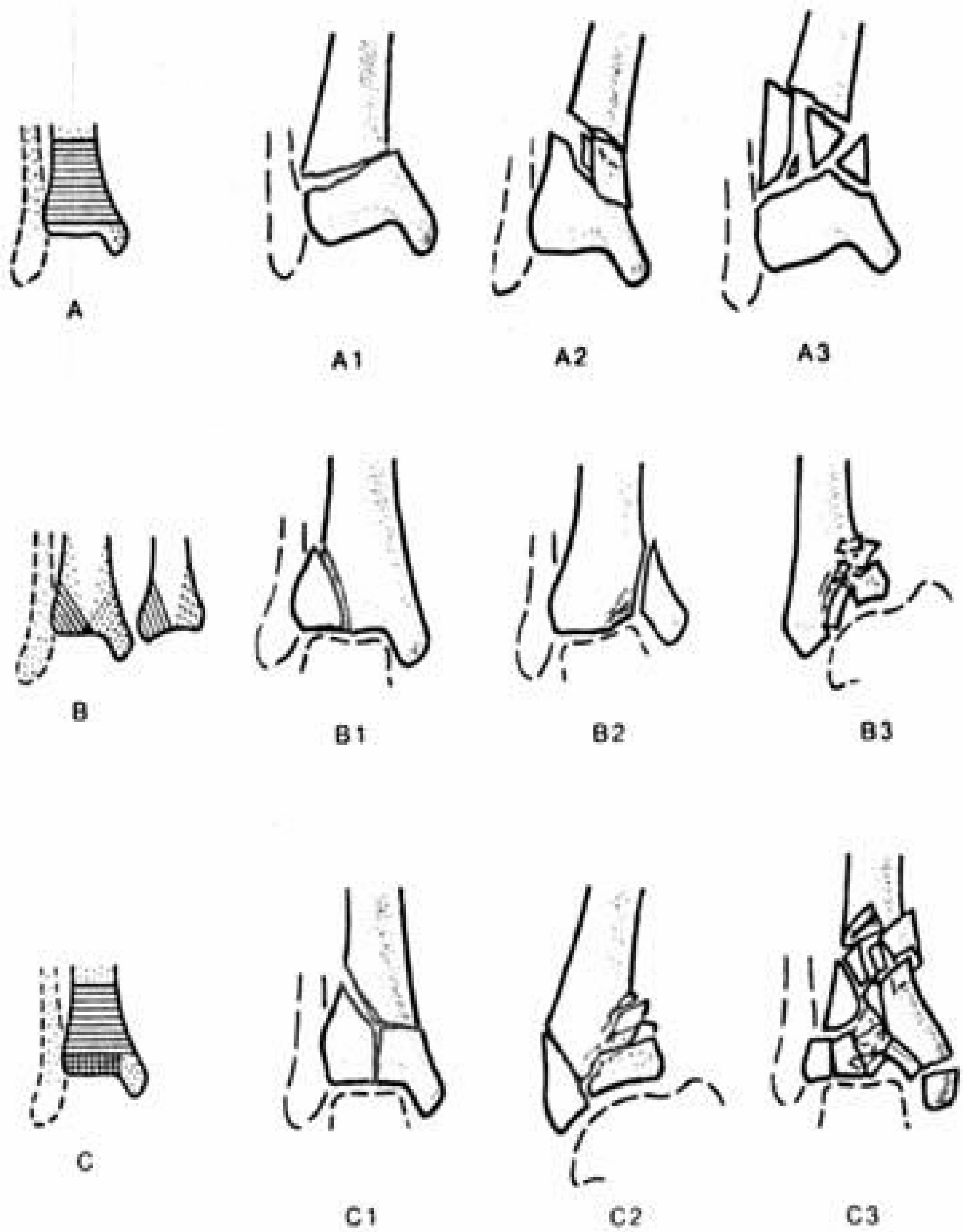
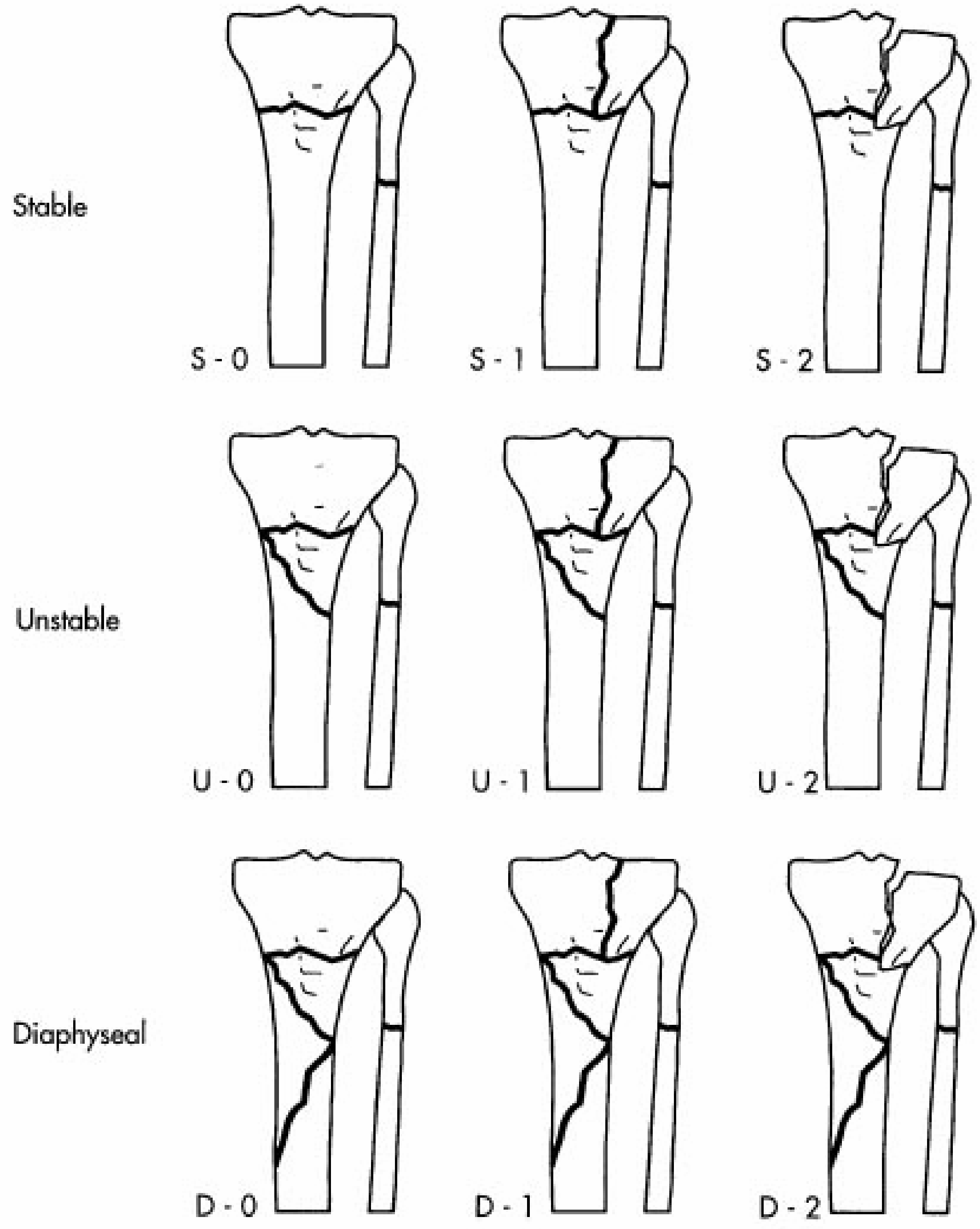
AO/OTA Classification of Proximal Tibial Metaphysis

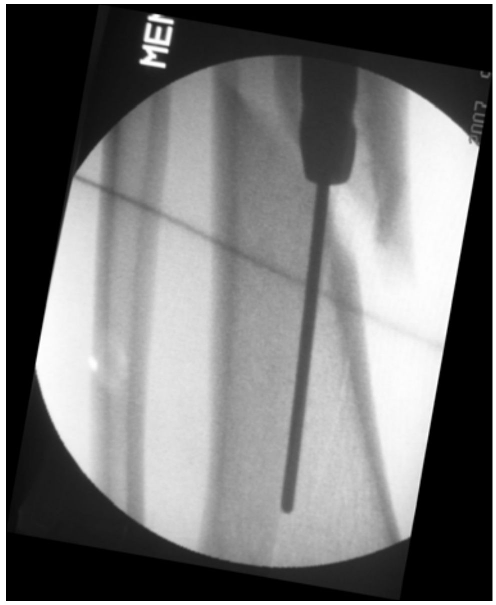


AO/OTA Classification of Distal Tibial Metaphysis

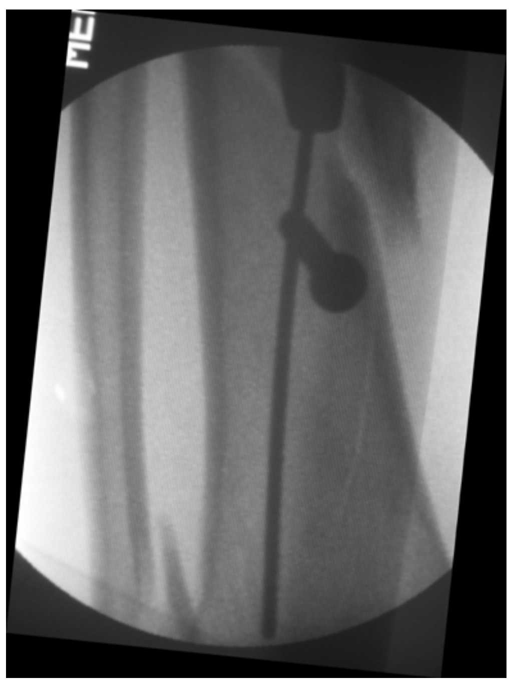


Taylor and Martin SUD classification of metaphyseal fractures





Varus alignment with nail in-situ



Poller screw on the concave side

Alignment restored as the nail introduced

Case 1

Pre operative X ray

Immediate post operative X ray
Alignment restored

Fracture union at 10 weeks
Alignment maintained

7 Months follow up X ray

Bearing weight at 6weeks post op

Knee movements at 6 weeks post op

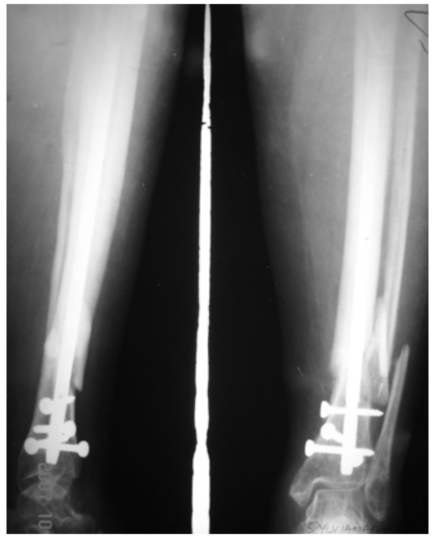
Ankle movements at 7 months post op

Subtalar movements at 7 months post op

Case 2

3.5 months after trauma
With varus and recurvatum

Immediate post operative X ray
Alignment restored

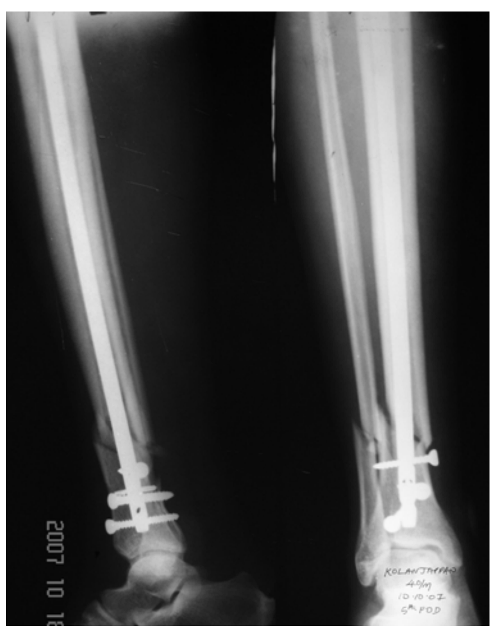


10 weeks follow up X ray
Alignment maintained

Bearing weight at 12 weeks
Alignment maintained

Case 3

Preoperative X ray
With valgus alignment



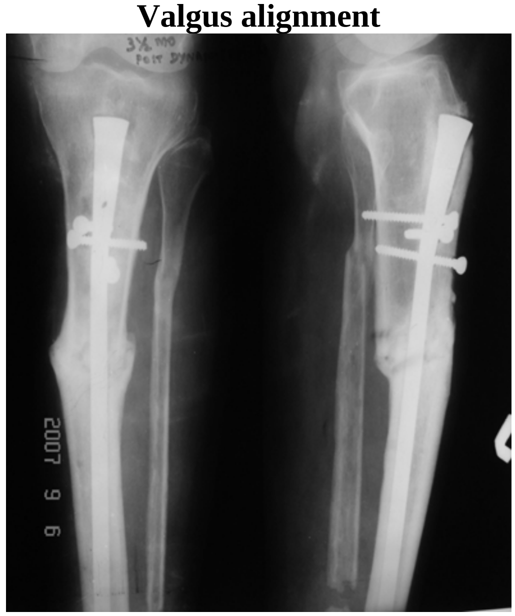
Post operative X ray
Alignment restored

Case 4

Immediate post trauma Xray
Valgus alignment

18 weeks post trauma
Valgus alignment

Immediate postoperative X ray
Valgus alignment



5 months follow up X ray
Union in valgus alignment
Loss of anteroposterior alignment

Movements at 5 months follow up

Case 5

Preoperative X ray
Varus alignment

Post operative X ray
Alignment restored

Case 6

Pre operative X ray
Varus alignment

Post operative X ray
New fracture line through Poller screw
Alignment restored

10 weeks follow up
Fracture united
Alignment maintained

Proforma

Use of poller screw in fracture proximal and distal third tibia.

Sl.No :

Patient name :

Age/Sex : IP No:

Occupation :

Address :

Phone no :

Date of injury :

Mode of injury : Side : Right/Left

Fracture classification

AO :

Simple/compound (Grade)

Fracture pattern

	Distance from tibial plateau/ Plafond	Length of fracture	Comminution	Preop Angulation Varus /valgus and Ante/Recurvatum	Post op	At union
Proximal/ Distal 3rd						

Diameter of medullary canal

At isthmus

At the level of fracture

Proximal metaphysis

Distal metaphysis

Level of fibula fracture :

Associated injuries :

Interval between injury & surgery :

Reduction : CRIF/ORIF

Nail size :

No of screws

Prximal locking :

Distal locking :

Poller screws :

Purpose of poller screw

- To correct alignment after nail insertion
- To maintain alignment or to improve the stability of bone implant complex
- To control the nail during insertion

Weight bearing started on :

Cast support : Yes/No

Time for union :

Complication :

Secondary procedures

Final outcome :

Karlstorm – Olerud Score(0-7 points):

Residual angulation (0-3) :

Fracture healing (0-3) :

Cast support (0-1) :

MASTER CHART

Sl. No	Age	Sex	Side	Simple/ compound	AO Type	Delay (In weeks)	Distance from joint line (in cm)	Length of fracture (in cm)	Reduction OR/CR	Nail size (in mm)	Valgus/Varus angulation (in degrees)			Ante/Recurvatum (in degrees)			Locking screws		Poller	pur-pose	Fibula fracture level	Wt bearing started (In weeks)	Time for union (in weeks)	Score	Outcome
											preop	post op	At union	pre-op	post -op	At union	prox	distal							
1	45	M	L	S	B	18	9(P)	2.5	CR	8/ 340	+13	+6	+6	0	0	+2	1	2	2	2,3	S	4	22	5	F
2	60	M	L	S	A	4	3	3	CR	8/ 340	+14	0	0	-24	0	0	1	2	1	2	S	4	10	0	E
3	34	M	R	S	B	5	2	5	CR	8/ 320	-12	-7	-7	-2	0	0	2	3	1	1,2	P	2	10	1	E
4	45	M	L	S	B	1	6	7	CR	9/ 360	+14	+8	+8	-8	0	0	2	3	2	1,2	S	2	10	3	G
5	34	M	L	S	B	2.5	3.5	4.5	CR	9/ 340	+9	+2	+2	-2	-2	-2	2	2	2	2,3	S	0.5	8	1	E
6	45	F	R	S	A	0.5	5	0.5	CR	9/ 280	+11	0	0	+6	0	0	1	2	1	1,2	S	0.5	10	0	E
7	45	F	L	GR II	B	18	3.5	3	**OR**	7/ 260	-8	0	0	-20	0	0	1	2	2	2	S	10	12	1	E
8	26	M	R	S	A	1.5	8	3	CR	9/ 340	-20	0	0	+15	0	0	1	2	2	2	S	0.5	10	0	E
9	47	M	R	GR I	C	2	3	4.5	CR	8/ 360	-8	-2	-2	-16	0	0	1	2	1	2,3	D	2	12	2	G
10	36	M	R	S	B	1.5	9	4	CR	9/ 360	+5	0	0	0	0	0	1	2	2	2	SS	3	10	0	E
11	26	M	L	S	B	0	4	3	CR	9/ 360	+8	0	0	+10	0	0	1	2	2	1,2	S	1	10	0	E
12	47	M	R	S	A	2	8	4	CR	9/ 320	-14	-2	-2	+18	0	0	1	2	1	1,2	D	4	12	2	G
13	34	M	R	GR II	C	4	5.5	4	**OR**	8/ 360	-14	+7	+7	+10	0	0	1	2	1	1,2	SS	4	14	5	F
14	24	M	R	GR I	B	1.5	9	4	CR	8/ 340	+2	0	0	-8	0	0	1	2	2	2	I	2	10	0	E
15	24	M	R	GR I	B	10	6	0.5	CR	8/ 360	+1	+1	+1	-2	-2	-2	1	2	2	2	S	1	10	1	E
16	40	M	R	GR II	B	0.5	3	5	CR	8/ 320	+8	0	0	+2	0	0	1	1	2	2	S	2	10	1	E
17	45	F	L	S	B	2	4(P)	2	CR	8/ 340	+9	+2	+2	+4	0	0	2	2	2	2,3	S	2	14	2	G
18	26	M	R	S	C	0.5	6(P)	3	CR	8/ 360	-10	0	0	-2	0	0	2	2	1	2	S	2	10	0	E
19	30	F	L	GR I	A	0.5	3(P)	2.5	CR	8/ 340	+14	0	0	4	0	0	2	2	2	1,2	S	2	12	0	E
20	42	M	R	S	C	0	5	3	CR	8/ 360	-12	-1	-1	-6	0	0	1	2	1	1,2	S	2	14	2	G